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# Maintenance Trends in ERP Systems

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## ABSTRACT

During the late 1990's, many Japanese firms replaced their legacy and traditional enterprise information systems with ERP (Enterprise Resource Planning) systems. These systems cannot continue in use without maintenance. However, the maintenance of ERP systems differs from maintenance of traditional custom-built information systems. Moreover, maintenance requirements are known to change throughout in the operational phase. This study investigated the actual occurrence frequency of maintenance tasks classified into 6 categories during each month in five years (60 months) of ERP operation after go-live in three case studies of Japanese manufacturing firms. Through this investigation, this study identified clear the maintenance trends common to three firms, based on the maintenance occurrence frequencies in each firm.

## Keywords

Maintenance, Enterprise Resource Planning (ERP) systems, Case study of Japanese manufacturing firms

## INTRODUCTION

During the late 1990's many Japanese firms implemented ERP (Enterprise Resource Planning) systems, in each case replacing their legacy and traditional custom-built enterprise information systems with new package-based systems configured to fit new business rules. These implemented information systems cannot keep being used automatically for a long time without maintenance. Maintenance is indispensable for every system to adapt to changes in business environment and new rules in the operational phase after go-live over the life of the system (Burch&Grupe, 1993).

In general, software maintenance can be categorized into four types: corrective, adaptive, perfective, and preventive (April&Abran, 2008; Burch&Grupe, 1993; Grubb&Takang, 2003; Lientz et al., 1978; Marquez, 2007; Yang&Ward, 2003). However, more important issues are not to classify maintenance, but to manage or control these maintenance categories in the operation of the information systems appropriately. Kung&Hsu (1998) point out the software maintenance planning is very important to reduce maintenance cost, but most maintenance strategy is reactive to respond rapidly to changing requests. They proposed a Software Maintenance Life Cycle (SMLC) model which consists of the four stages: introduction, growth, maturity, and decline stage, and showed the change of maintenance requests based on the monitoring survey of two cases.

Maintenance trends of ERP systems are different from that of traditional custom-built information systems because the user organization more strongly relies on the external partners, such as package vendors, system integrators, and consulting firms, which have a special skill and much experience for ERP implementations and operations (Nah et al., 2001; Yokota&Yauda, 2003). In addition, user training and education are also more important to use the ERP system effectively. Therefore, Kung&Hsu's SMLC model does not necessarily adapt to recent package-based information systems directly.

Though it is important for every user organization to design the process of the maintenance management, the fact is that the studies which are focusing on the maintenance activity in operation phase are a little. Early ERP research has covered many aspects of ERP implementation. It has focused mainly on the earlier stages of the ERP lifecycle. Therefore, this study investigated the actual occurrence frequency of maintenance tasks classified into 6 categories in each month in five years (60 months) ERP operation, based on three case studies of Japanese manufacturing firms. The research question addressed in this study is:

*What is the nature and frequency of maintenance of ERP systems in Japanese manufacturing firms?*

Through this investigation, the goal of this study makes clear the maintenance trends common to three firms based on the transition process of these occurrence frequencies in each firm.

## ORVERVIEW OF MAINTENANCE

### Characteristics and Maintenance Categories on ERP Systems

Many ERP systems were implemented by the major Japanese manufacturing firms during the late 1990's, and various subsystems have been added and a lot of functions have been improved and enhanced during the decade until today. There are mainly following three reasons about the necessity of the maintenance of the ERP systems (Yokota&Yasuda, 2006): (1) the reinforcement of the package function or the improvement of software structure that was not assumed in ERP system implementation, (2) the movement of a common IT and the change of the organizational business environment and rules, and (3) the adoption and/or adaption of the best practice business model embedded within the software through the reengineering activity. However, ERP systems have different characteristics from traditional custom-built information systems in the following two ways:

(a) ERP systems are said to embed "the best practice business models" which are success cases of the business process based on the implementation experience in various industries by package vendors. The implementation of the ERP systems can reduce the time of the business analysis, the system design, and programming by using these best practice business models. On the other hand, the user organization is required to adapt and change their existing business process to new one based on the best practice models. User organizations have to also strongly support the end users to adapt their business activities to the new business process and ERP system through user education and training.

(b) Enterprise Systems (ES) are inseparable from the business processes (Davenport, 2000), and there are recursive relations between the IT capability and the business process redesign (Davenport&Short, 1990). This is considerably different from traditional custom-built information systems which have been only maintained to fit an existing business process. Thus, Nah et al. (2001) point out that the user organizations more strongly depend on the external parties, such as package vendors, system integrators, and consulting firms, which have special skills and much experience for ERP system implementations and operations. Davenport (2000) also similarly points out that the user tends to depend on the external IT specialist as ES becomes complex and comprehensive. In addition, it is indispensable to take understanding and cooperation from business partners, which exchange an electronic data directly by ERP system, as external parties.

Based on these characteristics of ERP systems, Nah et al. (2001) classified ERP maintenance tasks into 6 categories in their empirical study on the ERP maintenance activities. Table 1 shows the maintenance categories for the ERP systems based on their 6 classifications. It includes 4 same categories of the general software maintenance, such as (1) collective maintenance, (2) adaptive maintenance, (3) perfective maintenance, and (4) preventive maintenance. However, the descriptions of the task in each maintenance category are not necessarily the same as the traditional custom-built information systems. In addition, Nah et al. (2001) insist on the necessity of new 2 maintenance categories for ERP maintenance, and that is (5) user support and (6) external party.

### Why Investigate Maintenance Activities in ERP Systems?

It is important to follow up the trends and characteristics of maintenance tasks on the system operation because we are able to guess easily that the same maintenance will not always remain critical throughout in the operational phase. Firstly, Kung&Hsu (1998) proposed Software Maintenance Life Cycle (SMLC) model based on Product Life Cycle (PLC), which consists of the four stages: introduction stage, growth stage, maturity stage, and decline stage. In addition, Kung&Hsu classified the maintenance request into "user support", "repair", and "enhancement" and indicated that main maintenance requests changed sequentially from the user support to the repair and from the repair to the enhancement based on the monitoring survey of two cases. These changes of the maintenance requests mean the "trigger" into which the stage changes in their study.

The SMLC model, which related each maintenance request to each stage, provides a general picture of the transition of the software maintenance, and it is very useful in order to consider about a maintenance framework. However, the SMLC model is not an investigation on the recent package-based information systems, but an investigation on the traditional custom-built information systems. On the other hand, the investigation of Nah et al. did not divide the stages by the change of the occurrence frequency of maintenance tasks and did not make clear the triggers that shift the stage. At this point, the investigation of Nah et al. is different from that of Kung&Hsu (1998).

## DESCRIPTION OF CASE STUDY FIRMS

This study investigated the actual occurrence frequency of maintenance tasks classified into 6 categories on each month in 5 years (60 months) of ERP operation based on three empirical case studies of Japanese manufacturing firms. This study makes

Maintenance categories	Maintenance tasks
(1) Corrective maintenance	<ul style="list-style-type: none"> <li>● Application of hot packs and/or bug fix Incorporating system patches sent by ERP vendors in cases where the problems could not be resolved by the IT department</li> <li>● Troubleshooting Resolving of anomalies reported by users</li> <li>● Import new objects from ERP vendors Incorporating objects (lines of code) sent by ERP vendors to solve some problems (for examples include new database structures, programs, and new reports)</li> </ul>
(2) Adaptive maintenance	<ul style="list-style-type: none"> <li>● Configuration change and verification Verification after adaptation of hot pack application and change of configurations</li> <li>● Improvement and modification Customization and modification performed to keep adapting to business changes and to fit new business rules</li> <li>● User management Managing the access permissions when staff arrived, leaved, or changed positions</li> <li>● Tuning of system interfaces Tuning of system interfaces to link with other vender's software or other organization's systems</li> </ul>
(3) Perfective maintenance	<ul style="list-style-type: none"> <li>● Version upgrade Justification, planning, and implementation of new versions</li> <li>● Addition and enhancement Adding or developing the new functions, and/or enhancing or expanding the existing functions</li> </ul>
(4) Preventive maintenance	<ul style="list-style-type: none"> <li>● Routine administration and monitoring Monitoring average system response times and thresholds, file sizes, tape backups, and error logs</li> </ul>
(5) User support	<ul style="list-style-type: none"> <li>● User Training Training users to use the new system and to fit to the new business process</li> <li>● Help desk Answering for user questions and inquiries about the system use</li> </ul>
(6) External party	<ul style="list-style-type: none"> <li>● Coordination and administration Coordinating work and relation among ERP vendor, consultants, and external user organizations</li> <li>● Creation of online service system notes Online query or reporting of problems to the vendor Tracking vendor's progress towards resolution of problems reported</li> </ul>

Source: Nah, et al. (2001). (This table modified a part of their study.)

**Table 1. Classification of maintenance tasks into maintenance categories**

clear the maintenance trends common to three firms based on the transition process of these occurrence frequencies in each firm.

This study collected the data of the maintenance tasks that take place after the ERP system goes-live by the visit and interview investigation to three Japanese manufacturing firms. The investigation period was from December, 2007 to September, 2008. We were permitted to enter to the information system section with cooperation of CEO and CIO of each firm. This study verified all the recorded trouble reports, defect reports, maintenance request and maintenance reports, and the system logs in 5 years ERP operation on three investigation firms after the ERP system goes-live. Based on this verification work, this study classified all the confirmed and recorded maintenance tasks into 6 categories and counted the number of maintenance in each month. (The three firms were not prepared to allow the researcher to report the cost of these maintenance activities.)

The three Japanese manufacturing firms investigated in this study have used SAP R/3 as their ERP systems since 2002 for Company A, 2001 for Company B, and 1999 for Company C. All these firms are huge enterprises, which have been listed on the First Section of the Tokyo Stock Exchange and have the capital more than 35 billion yen (currently approximately 420 million US dollars). However the implementation purpose and scale size of the ERP system on three firms are not same.

### *Company A*

ERP system had been implemented as a method to replace the old enterprise systems. The implemented modules are mainly management accounting and financial management. The number of employees of Company A is approximately 9,000, and the implemented ERP system has been used in 3 business units where about 5500 employees belong.

### *Company B*

ERP system on Company B had been implemented for restructuring both old information systems and business process at the same time. It linked all information between all sections and departments and enabled users to access the unified information on real time. Currently, it has been used on the business including accounting, human resource management, production management, sales management, and quality control, mainly in 6 business divisions where about 12000 employees<sup>7</sup> belong.

### *Company C*

The ERP system had been implemented for optimizing the company wide business processes and exchanging the data between the information systems of business partners automatically by using the Supply Chain Management (SCM) system. Company C implemented most functions of the ERP system at the same time in head office and 8 production divisions. Currently, it has been used on the company wide businesses, which about 100,000 employees<sup>7</sup> belong, including not only accounting, human resource management, production management, sales management, and quality control, but also inventory control with linked external businesses partners by SCM.

## **RESULTS: TRENDS OF ERP MAINTENANCE FREQUENCY**

### **Collected data of maintenance tasks**

Table 2 shows the number and ratio of maintenance tasks that took place in each maintenance category in 5 years ERP operation in each firm. The more the scale of the covered business by ERP system is expanded, the more the number of the maintenance tasks increases. However, Table 2 is indicating that there is not extreme difference between the ratios of each maintenance category in three firms.

Figures 1-3 show actual occurrence frequency of maintenance tasks classified into 6 categories in each firm. From these figures, the trends of the transition process in the occurrence frequency of the maintenance tasks on three firms are similar, and chiefly, three changes are found in the transition process. This study divides 5 years ERP operation into three terms based on the changes in the transition process of the maintenance frequency.

### **Trends of each term**

#### *Term-1*

The term-1 was roughly 15 months between the 1st month and the 15th month. The occurrence frequencies in 5 maintenance categories, except for perfective maintenance, are increasing immediately after having started the operation and these frequencies were the highest during the 5 years studied. Especially, the frequency of user support is higher than that of other maintenance categories in all firms. However, all frequencies are decreasing rapidly between the 5th month and the 15th month. As a whole, the frequency of maintenance categories decreases in this term from the trend of each figure, Figure 1-3. From these trends, the term-1 is the process from which the user organization adapts oneself to the implemented information system, and also, the term-1 is a run-up to the stable use of the system.

#### *Term-2*

The term-2 was roughly 21 months between the 16th month and the 36th month. There is the month when the frequency of several maintenance categories increases temporarily, however the frequencies of all maintenance categories were almost constant every month on the whole. Above all, the monitoring of the system conditions is an important maintenance task because preventive maintenance has been keeping constant high occurrence frequency in this term. These trends indicate that the system had been driven with stable use and condition in the term-2.

#### *Term-3*

The term-3 was roughly 24 months between the 37th month and the 60th month. In general, the frequency of all maintenance categories tends to increase again at this term. Especially, the frequency of adaptive maintenance or perfective maintenance is

Investigation firms	Maintenance categories and tasks						Total
	(1) Corrective maintenance	(2) Adaptive maintenance	(3) Perfective maintenance	(4) Preventive maintenance	(5) User support	(6) External party	
Company A	<ul style="list-style-type: none"> <li>● Application of hot packs and/or bug fix</li> <li>● Troubleshooting</li> </ul>	<ul style="list-style-type: none"> <li>● Configuration change and verification</li> <li>● Modifications and enhancements</li> </ul>	<ul style="list-style-type: none"> <li>● Version upgrade</li> </ul>	<ul style="list-style-type: none"> <li>● Routine administration and monitoring</li> </ul>	<ul style="list-style-type: none"> <li>● User Training</li> </ul>	<ul style="list-style-type: none"> <li>● Coordination and administration</li> </ul>	
Number of maintenance tasks	177	313	135	1,019	594	425	2,663
(Ratio)	(6.6%)	(11.8%)	(5.1%)	(38.3%)	(22.3%)	(16.0%)	(100.0%)
Company B	<ul style="list-style-type: none"> <li>● Application of hot packs and/or bug fix</li> <li>● Troubleshooting</li> <li>● Import new objects from ERP vendors</li> </ul>	<ul style="list-style-type: none"> <li>● Configuration change and verification</li> <li>● Improvement and modification</li> <li>● User management</li> </ul>	<ul style="list-style-type: none"> <li>● Version upgrade</li> <li>● Addition and enhancement</li> </ul>	<ul style="list-style-type: none"> <li>● Routine administration and monitoring</li> </ul>	<ul style="list-style-type: none"> <li>● User Training</li> <li>● Help desk</li> </ul>	<ul style="list-style-type: none"> <li>● Coordination and administration</li> <li>● Creation of online service system notes</li> </ul>	
Number of maintenance tasks	582	1,049	583	2,398	2,004	1,210	7,826
(Ratio)	(7.4%)	(13.4%)	(7.4%)	(30.6%)	(25.6%)	(15.5%)	(100.0%)
Company C	<ul style="list-style-type: none"> <li>● Application of hot packs and/or bug fix</li> <li>● Troubleshooting</li> <li>● Import new objects from ERP vendors</li> </ul>	<ul style="list-style-type: none"> <li>● Configuration change and verification</li> <li>● Improvement and modification</li> <li>● User management</li> <li>● Tuning of system interfaces</li> </ul>	<ul style="list-style-type: none"> <li>● Version upgrade</li> <li>● Addition and enhancement</li> </ul>	<ul style="list-style-type: none"> <li>● Routine administration and monitoring</li> </ul>	<ul style="list-style-type: none"> <li>● User Training</li> <li>● Help desk</li> </ul>	<ul style="list-style-type: none"> <li>● Coordination and administration</li> <li>● Creation of online service system notes</li> </ul>	
Number of maintenance tasks	422	1,656	330	3,181	1,256	1,402	8,247
(Ratio)	(5.1%)	(20.1%)	(4.0%)	(38.6%)	(15.2%)	(17.0%)	(100.0%)

**Table 2. Number of Maintenance Tasks in Investigated firms in the 5 Years After Go-Live**

increasing on each firm. This was caused by the fact that improvement, upgrade, or expansion was performed in three firms: Upgrade was carried out in Company A, the addition of the function was carried out in Company B, and the setting change and adjustment of the interface were carried out in Company C in order to construct the additional SCM between business partners. The occurrence of these maintenances, which were categorized into adaptive maintenance or perfective maintenance, was factor to cause the occurrence of other maintenances. For instance, it is necessary for the troubleshooting to be done immediately when troubles were pointed out by users. It is also necessary to keep monitoring the system conditions and status carefully to prevent a defect and trouble beforehand. Furthermore, the user support, which includes the user training to cover new knowledge and skills, and the help desk to accept inquiries from end users, is required by the system improvement. In addition, the cooperation from the external parties or business partners is indispensable for the improvement of the system. From these trends, the term-3 is a process from which function enhancement and the performance improvement were planned and carried out to the system.

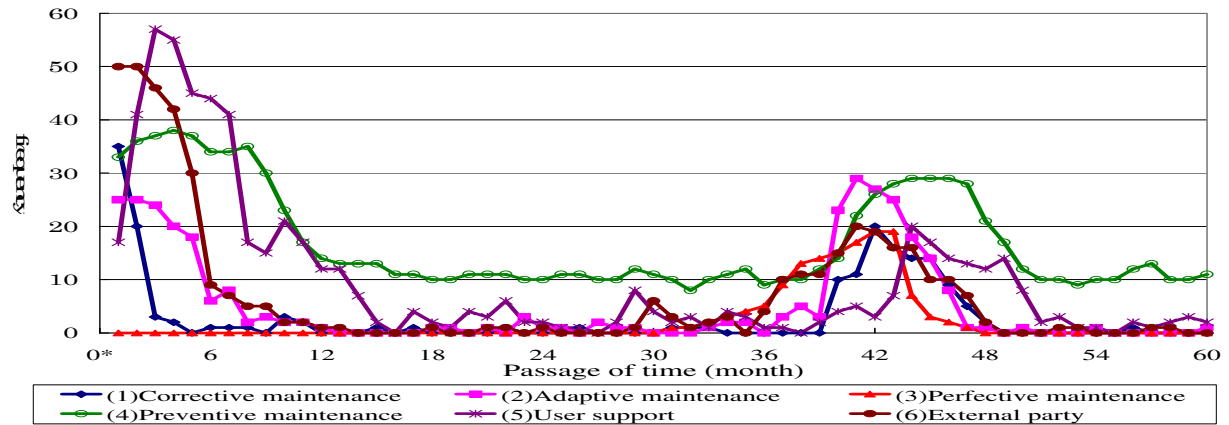


Figure 1: Transition of frequency on 6 maintenance categories in Company A

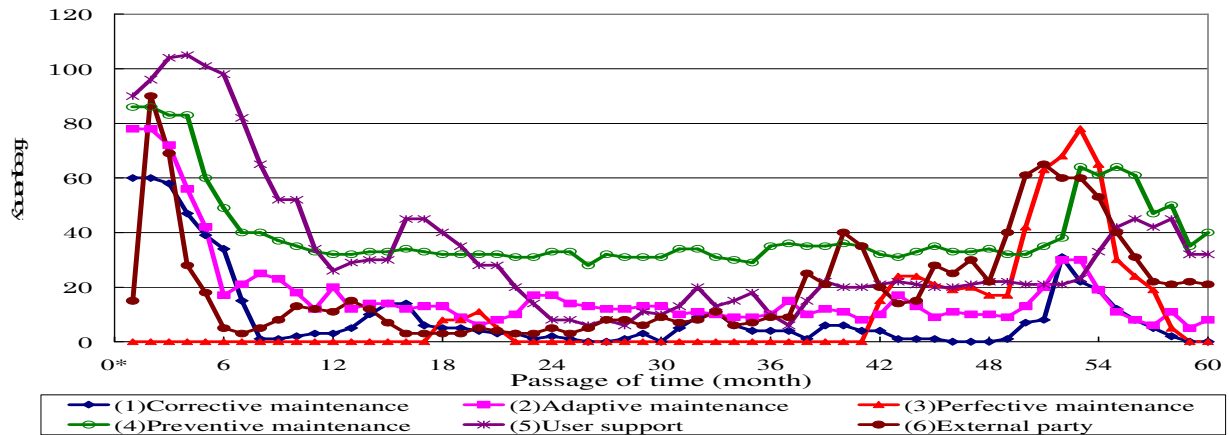


Figure 2: Transition of frequency on 6 maintenance categories in Company B

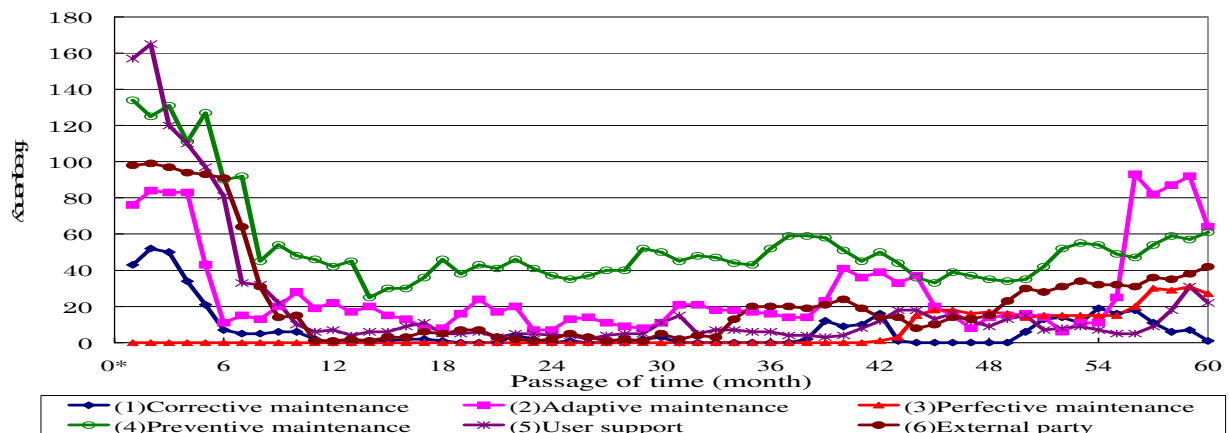


Figure 3: Transition of frequency on 6 maintenance categories in Company C

## DISCUSSION

This study investigated the actual occurrence frequency of maintenance tasks classified into 6 categories based on the Nah et al. (2001) ERP maintenance classification framework on each month in 5 years of ERP operation by three empirical case studies of Japanese manufacturing firms. Kung&Hsu (1998) classified the maintenance request into “user support”, “repair”, and “enhancement”, and they indicated that main maintenance requests changed sequentially from the user support to the repair and from the repair to the enhancement based on the monitoring survey of two cases. They also proposed a Software Maintenance Life Cycle (SMLC) model which consists of the four stages, and they consider these changes of the maintenance requests to be the trigger that moves to next stage on the SMLC model. On the other hand, Nah et al. (2001) classified ERP maintenance tasks more accurately, however, the work of Nah et al. (2001) was based on the four stages of Kung&Hsu’s SMLC model, and measured frequencies of the maintenance tasks on each stage. Therefore, the division of the stages in the investigation of Nah et al. was not based on the changes in the occurrence frequencies of maintenance tasks. This study is different from their study at the following two points.

(a)The division of the stage concerning the information system under the operation is very difficult. Even studies of Kung&Hsu and Nah et al. did not deal with the decline stage, which is the last stage of SMLC model. This study divided investigated period, 5 years of ERP operation, by the trends of the changes of frequencies of each maintenance category as well as Kung&Hsu’s study. However, this is not showing the life cycle of the operational phase of ERP systems but showing one cycle of the maintenance activity on the ERP systems because this study expect that the term-2 and the term-3 will appear repeatedly in the future of the ERP operation. This also is a considerably different point between this study and existing studies based on SMLC model which have been argued only in four stages.

(b)From the transition processes and the trends of these similar maintenance frequencies on three companies, this study conceives there are the maintenance categories that the changes of the frequency were synchronizing with the occurrence of other maintenance categories. Maintenance categories of user support, preventive maintenance, and external party were the critical activity in the term-1, and especially, user support seems to be the key maintenance category in term-1 because the frequency of user support is higher than that of other maintenance categories in all companies. In the other side, the improvement activity including adaptive maintenance and/or perfective maintenance seems to be the key maintenance category not in the term-1, but in the term-3 because the frequencies of these maintenances categories rose in three firms. The occurrence of these maintenances was being the factor to cause the occurrence of other maintenances, especially such as user support, preventive maintenance, and external party in the term-3. This is point different from the study of Nah et al.(2001) that the frequency of only perfective maintenance was increasing on a maturity stage in contrast to the frequencies of other five maintenance categories which were decreasing.

After stabilizing the system, the organization can gain the benefits from the implemented information systems. Seddon et al. (2010) pointed out that four additional factors, namely integration, process optimization, improved access to information, and on-going major ES business improvement projects, drive organizational benefits from ES over the long term. Their points overlap in a phenomenon of the increase of each maintenance category on term-3 in this study. In this study, the term-3 was the time when the ERP systems were just stably used in each firm, and also this study conceives that the term-3 was the time when the maintenance concerning four additional factors, which Seddon et al. pointed out, as adaptive maintenance or perfective maintenance were strongly requested to drive organizational benefits from ERP systems over the long term.

## CONCLUSION

This study investigated the transitions of occurrence frequencies of the maintenance tasks classified into 6 categories for every month in 5 years ERP operation after the system goes-live based on three case studies of Japanese manufacturing firms. There were the three changes in the transition process over 5 years of ERP operation.

The term-1, between the 1st month and roughly the 15th month, is the process from which the user organization adapts itself to the implemented information system, and also, the term-1 is a run-up to the stable use of the system. The occurrence frequency in all maintenance categories increased immediately after go-live. However, the frequency of these maintenance categories decreased rapidly between the 5th month and the 15th month.

The term-2, between roughly the 16th month and the 36th month, is the process from which the system had been driven with stable use and condition. The frequency of all maintenance categories is almost constant every month. The preventive maintenance has been keeping constant high occurrence frequency, therefore, the monitoring of the system conditions is an important maintenance task in this term.

The term-3, between roughly the 37th month and the 60th month, is a process from which function enhancement and the performance improvement were planned and carried out to the system. The frequency of all maintenance categories tends to



increase all in all. Especially, the adaptive maintenance or perfective maintenance is increasing because three firms had carried out the maintenance concerning the improvement, update, and enhancement in this term.

The contribution of this study is to have shown that in addition to providing evidence of the validity and usefulness of the Nah et al. (2001) ERP maintenance classification framework, and of the variation in frequency of different maintenance activities over their three stages (Introduction, Growth, and Maturity), the pattern of variation of maintenance activities in the three Japanese firms was not the same as in the three organizations studied by Nah et al. In this study, in two of the three firms the pattern was similar to Nah et al. (2001) in the first two terms, but (a) the large increase in maintenance term-3 in this study was not reported by Nah et al. and (b) the rise in perfective maintenance reported by Nah et al. was due to efforts by the three firms to improve their ERP systems in some way (an upgrade in Company A, addition of new functionality in Company B, and an extension and addition of the SCM business partners in Company C). Further, the rise in perfective maintenance in the three Japanese manufacturing firms was accompanied by rises in many of the other categories of maintenance because of the scope of the changes being introduced. The term-3 rises in maintenance activities, are, however, highly consistent with the multi-project model reported by Seddon et al. (2010), who report that 71% of the 126 organizations in their sample had undertaken or were undertaking on-going improvement projects. (The current study provides much more detail about the nature of maintenance activities in these improvement projects.)

To what extent is it likely that the phenomena observed in these three firms are also likely to occur in other Japanese firms, or other ERP-using firms around the world? Combining the answers from this study with those of Nah et al. (2001), and insights from Seddon et al. (2010), it seems likely that because many firms (not just in Japan, and not just manufacturing firms) will find that they need to upgrade their software, improve processes, or add new functionality, it is expected that peaks in maintenance activities similar to those in term-3 in the three firms in this study will also be observed in many other firms.

Maintenance of ERP systems is indispensable to adapt the implemented systems to changes in business environment and new rules. However, the same maintenance will not always remain critical throughout in the operational. This study considers that the investigated period, 5 years of ERP operation, was one cycle of the maintenance on the ERP systems. That is to say, this study found that the term-2 and the term-3 will be repeated in the ERP operation of each firm in the future. This also is a considerably different point between this study and existing studies based on SMLC model which have been argued only in four stages. Therefore, it is necessary that the top management understands the natures and characteristics of ERP maintenance in advance to allocate a lot of and various resources such as budgets, human resources, equipments, and so on. The result of this study will be useful to plan the timing of maintenance in ERP operation and also to develop the conceptual framework for ERP maintenance management.

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